6 CALIBRATION

Calibration, as applied to the SFWMM, is the process by which model parameters are changed until a reasonable match between model output, primarily stage and discharge, and observed data is achieved. In this context, calibration can be more appropriately called history matching (Konikow and Bredehoeft, 1992). Model calibration relates to the assumption that a well calibrated model enhances its predictive capability.

SFWMM calibration was broken down into two non-overlapping geographical areas: the Everglades Agricultural Area, and the Everglades/Lower East Coast. Due to the unique way by which EAA is simulated in the model (refer to Sec. 3.3), only simulated runoff and demand volumes were compared with historical values. For the Everglades/LEC region, a set of water level monitoring/observation points and structure headwater stages were selected. Historical water level measurements at these locations and historical discharges through selected outlet structures were compared against stages and discharges simulated by the model, respectively. In order to keep model parameters up-to-date model calibration is performed on a regular basis. The results presented for the EAA calibration were based on SFWMM v3.2 while those corresponding to the Everglades/LEC region were based on SFWMM v2.8.

The following guidelines, which apply to hydrologic models in general, were used in calibrating the model:

1. The availability of historical stage and flow data dictated the extent of the calibration period. Rainfall, the primary driving force in South Florida's hydrology, further limits the length of time by which historical and simulated stages and/or flows are to be compared. The period of comparison should include extremely wet and dry conditions.

2. The historical (field-measured) data set should be limited by what can be considered reliable. For example, the quality of historical data on discharges at some coastal structures was considered poor. Flows through these structures, which were normally considered as boundary conditions, were simulated when the model was run in calibration mode. Therefore, after a field data verification process was conducted, graphical plots of simulated versus historical flow data were created.

3. The period of comparison should be short enough such that no significant changes in operational schemes occurs in the middle of the simulation period. This assumption is important since most of the parameters used in the model are time invariant. As contrasted to succession models, a long-term simulation model such as the SFWMM has limited capability in making changes to certain operating parameters in the middle of a simulation run. For example, the policy of holding back more runoff in the EAA due to Best Management Practice (BMP) has been implemented in the field only in the last few years. (This policy also impacts Lake Okeechobee water release rules.) However, it should either be continuously implemented or not at all in the 1965-1990 “base” case run in the SFWMM.

4. The frequency by which available historical data was compared should be consistent with regional modeling space and time resolution. For the SFWMM, comparisons are typically done only on a monthly basis: monthly total discharges, end-of-month nodal stages and monthly mean canal levels. The succeeding discussions on calibration results will address space resolution and model discretization issues to some extent.

5. Display calibration results by plotting historical and simulated values on the same graph (e.g. clustered bar graphs for flow comparison, XY or scatter plots for stage comparison) and quantifying goodness-of-fit by using some statistical measures (e.g. r-squared, bias).

The scope of the entire SFWMM calibration process can be divided into three parts:

1. Data update which includes time series (rainfall, reference ET, structure flows, stages at monitoring points and canals) and static data (land elevation, land use) updates;

2. Computer program update which involves changes to existing subroutines and/or creation of new computer code, e.g., improvements to ET and overland flow algorithms; and

3. Actual model calibration which requires accuracy checks on model algorithms, both old and new, and adjustments of model parameters that affect calculated water levels and discharges.

6.1 CALIBRATION OF THE EAA

The goal of the EAA calibration effort was to match, as close as possible, simulated irrigation requirements (demand) and runoff in the Everglades Agricultural Area. As mentioned earlier, the calibration of the EAA was performed in a way that differs from the rest of the model. Simulated flow volumes, both supplemental irrigation requirement and runoff, were compared to historical volumes. Due to the lack of groundwater data throughout the EAA, limited matching of historical water levels, specifically in the Rotenberger area, was performed. This procedure may not be a serious shortcoming because stages in the highly irrigated EAA are maintained within a very narrow range (Abtew and Khanal, 1992).

Methodology

The EAA calibration period was from January 1979 to December 1995 and version 3.2 of the SFWMM reflects the most up-to-date values of the calibration parameters. The selection of this calibration period took into account operational changes brought about by Best Management Practices (BMP) which modify the base operating rules for the EAA. Three parameters were adjusted during the EAA calibration: ET calibration coefficients **KCALIB**, and dimensionless local storage parameters **fracdph_min** and **fracdph_max** (refer to Sec. 3.3). Local storage parameters define the soil moisture level in the soil column at which runoff occurs and the level that triggers supplemental deliveries from other sources. All EAA calibration parameters vary monthly.

Since all parameters being adjusted were defined for each month, comparisons between historical and simulated monthly total long-term (averaged over calibration period) runoff and supplemental irrigation requirements were made. Runoff and supplemental irrigation requirements are defined as follows:

$$\text{Runoff} = \sum \text{structure outflows} - \sum \text{structure inflows}$$

$$= (S8 + S7 + S6 + S5A + S150 + G200 + G250) - (S3 + S2 + S352 + G88 + G136) \quad (6.1.1)$$

$$\text{Supplemental Irrigation} = \sum \text{structure inflows} - \sum \text{structure outflows} = (S3 + S2 + S352 + G88 + G136) - (S8 + S7 + S6 + S150 + S5A + G200 + G250) \quad (6.1.2)$$

The general rules for adjusting EAA parameters are shown in Table 6.1.1.

Table 6.1.1 General Rules Used in Adjusting Calibration Parameters for the Everglades Agricultural Area in the South Florida Water Management Model

Comparison of Runoff If simulated value is:	**Comparison of Supplemental Irrigation** If simulated value is:	**Action**
> Historical	< Historical	increase ET calibration coefficient, KCALIB
< Historical	> Historical	decrease ET calibration coefficient, KCALIB
> Historical	> Historical	increase local storage (decrease soil moisture level triggering supplemental deliveries and/or increase soil moisture level triggering runoff)
< Historical	< Historical	decrease local storage (increase soil moisture level triggering supplemental deliveries and/or decrease soil moisture level triggering runoff)

As mentioned in Sec. 3.3, the parameter KCALIB is used as an adjustment factor for a theoretical set of vegetation coefficients [KVEG in Eq. (3.3.1)] determined from an earlier study (Abtew and Khanal, 1992). The limits on KCALIB were established based on the desire not to alter the original values of KVEG significantly. The limits on parameters **fracdph_min** and **fracdph_max**, on the other hand, were established based on the assumption that the mean soil moisture level, (SOLCRNF+SOLCRT)÷2, does not vary substantially during the year. The final values of KCALIB, **fracdph_min** and **fracdph_max** are given in Table 6.1.2. The limits on soil moisture content, SOLCRT and SOLCRNF, can be calculated as the product of the assumed soil column depth (1.5 feet), the storage coefficient, and the limits on ratios fracdph_min and fracdph_max, respectively. SMAX and SMIN in Fig. 6.1.1 represent the limits on soil moisture content, expressed in terms of equivalent depths of water, in the unsaturated zone for a storage coefficient equal to 0.20.

The calibration parameters were adjusted until the mean monthly simulated and historical runoff and supplemental irrigation requirements (over the 1979-1995 time period) matched within one percent.

Table 6.1.2 Final Values of Parameters Used for the EAA Calibration in the SFWMM (v3.2)

Month	KCALIB	fracdph_max	fracdph_min
January	0.585	0.1607	0.0497
February	0.550	0.1277	0.0834
March	0.770	0.2300	0.0704
April	0.645	0.2564	0.0204
May	0.810	0.4218	0.0000
June	0.960	0.3511	0.0267
July	0.675	0.2307	0.0367
August	0.625	0.3454	0.0167
September	0.645	0.2857	0.0000
October	0.495	0.1920	0.0400
November	0.545	0.1850	0.0400
December	0.615	0.2607	0.0267

EAA Calibration Results

Time series plots comparing simulated and historical flow volumes for the entire EAA, and for each of the three subbasins simulated by the model, were prepared. Monthly total (Figs. 6.1.2 and 6.1.3), monthly average (Fig. 6.1.4), and annual total volumes (Fig. 6.1.5) were compared for the entire EAA. By plotting simulated versus historical values on the y- and x- axes, respectively, the goodness-of-fit for monthly runoff and monthly irrigation requirements can be evaluated (Figs. 6.1.6 and 6.1.7). A good fit is denoted by a regression line with a slope of unity and y-intercept at the origin. Appendix A contains additional EAA calibration plots not presented in this section.

Overall, differences between simulated and historical flow volumes can be attributed to a number of factors. They include:

1. errors in input data (static data, structure discharge, rainfall, etc.);
2. model inaccuracies due to model resolution (4-mile^2 grid cells, limited number of rainfall stations); and
3. oversimplified algorithm used to describe actual field-scale management of water by the farmers.

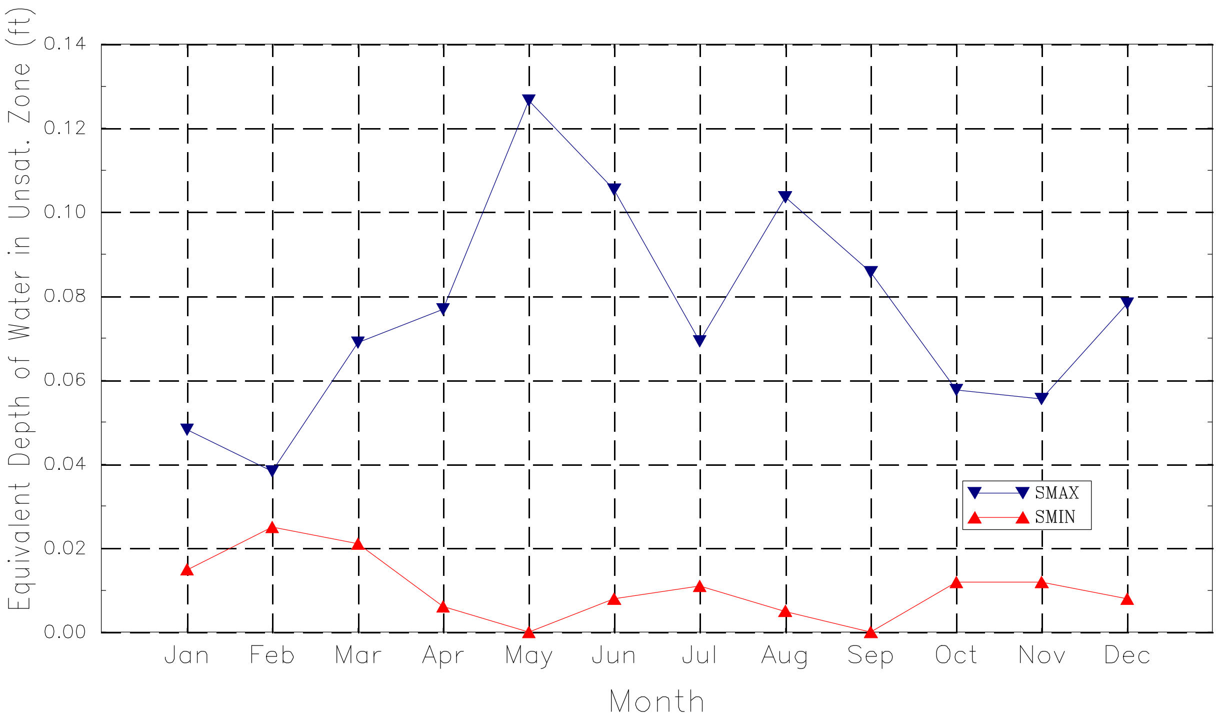

Figure 6.1.1 Everglades Agricultural Area Unsaturated Zone Storage Triggers for Runoff and Supplemental Flow as Implemented in the South Florida Water Management Model

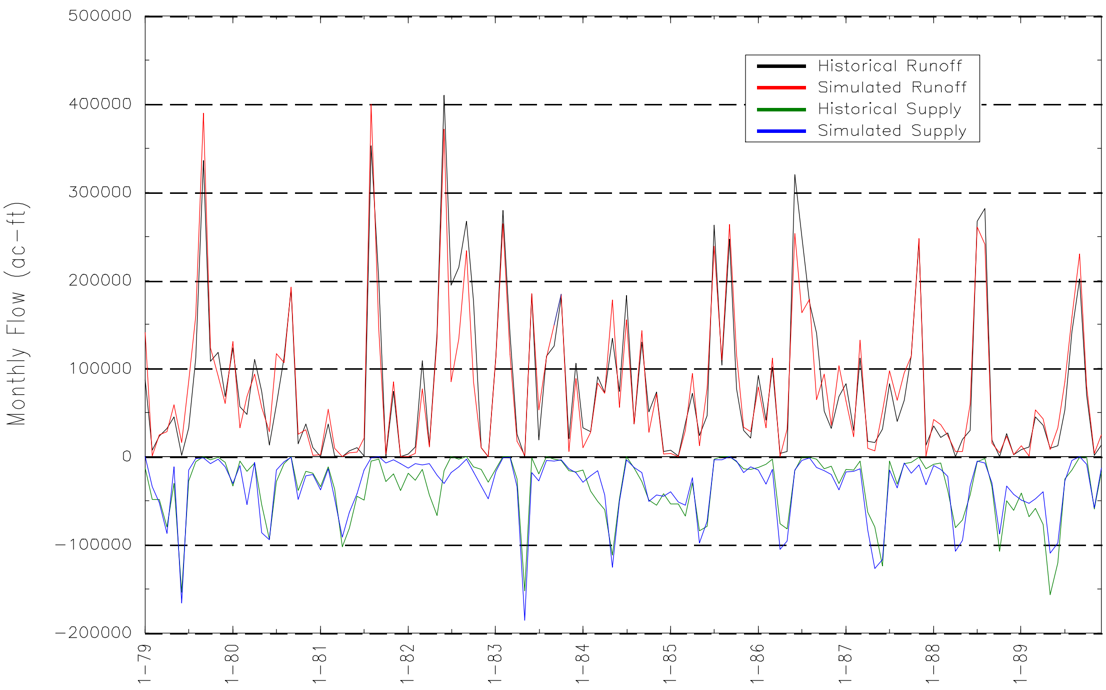

Figure 6.1.2 Comparison of SFWMM Simulated Monthly Runoff and Supplemental Flow for the Everglades Agricultural Area with Historical Data (1979-1989)

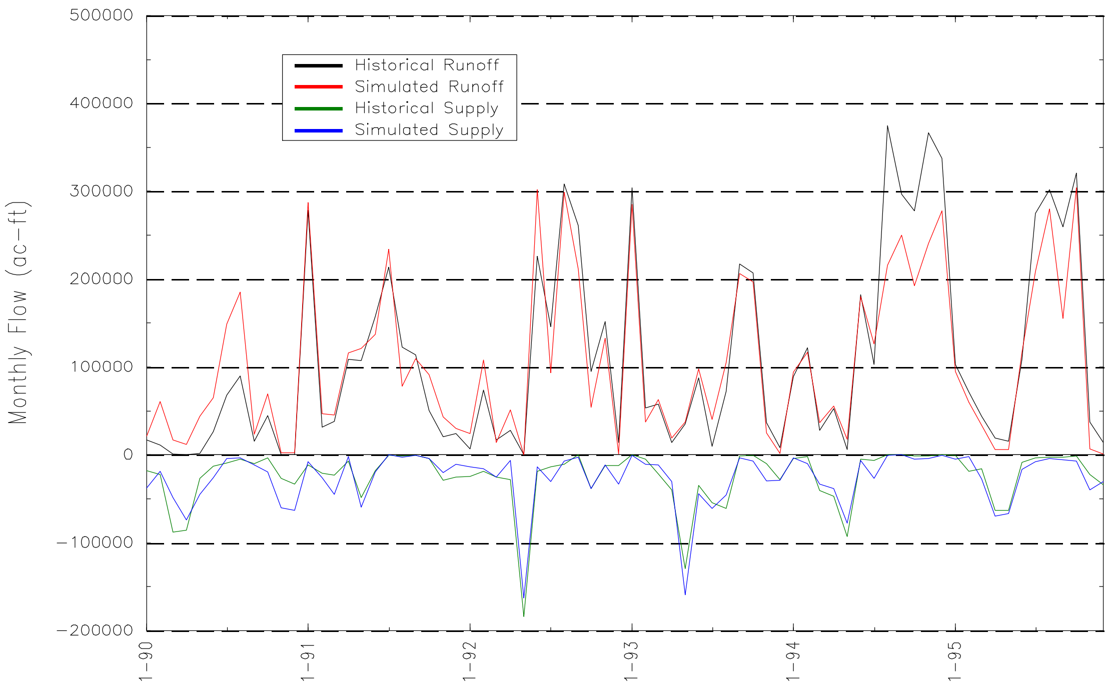

Figure 6.1.3 Comparison of SFWMM Simulated Monthly Runoff and Supplemental Flow for the Everglades Agricultural Area with Historical Data (1990-1995)

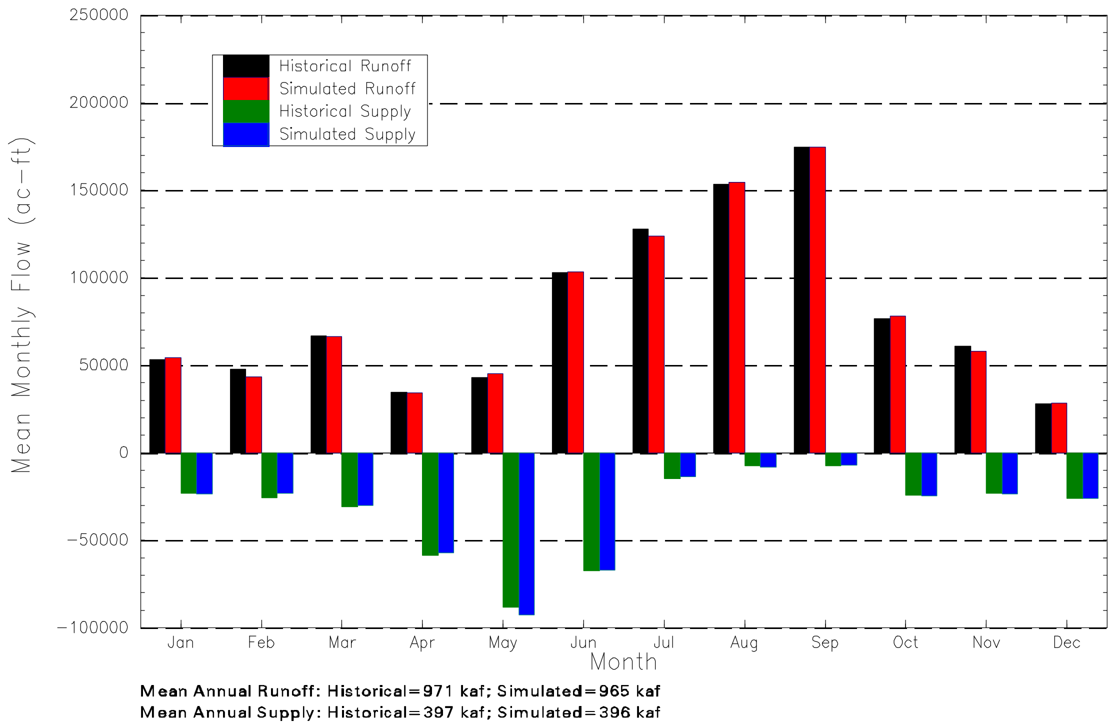

Figure 6.1.4 Comparison of SFWMM Simulated Mean Monthly Runoff and Supplemental Flow for the Everglades Agricultural Area with Historical Data (1979-1989)

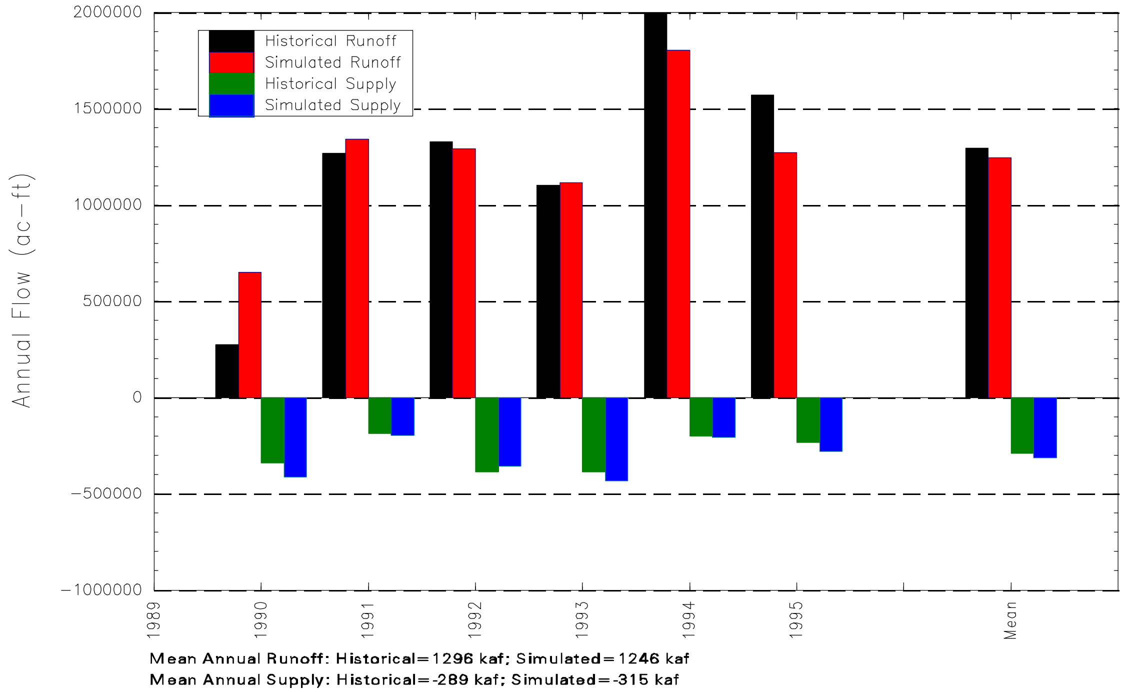

Figure 6.1.5 Comparison of SFWMM Simulated Annual Runoff and Supplemental Flow for the Everglades Agricultural Area with Historical Data (1990-1995)

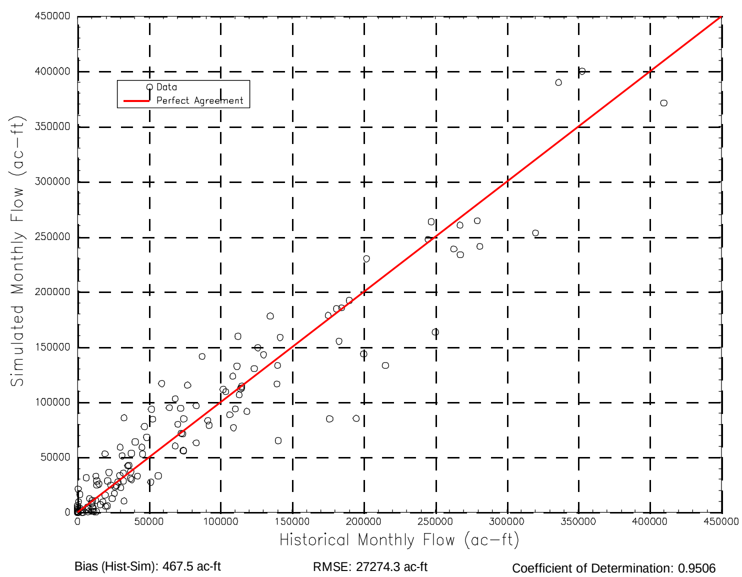

Figure 6.1.6 X-Y Plot of SFWMM Simulated Monthly Everglades Agricultural Area Runoff and Historical Data (1979-1989)

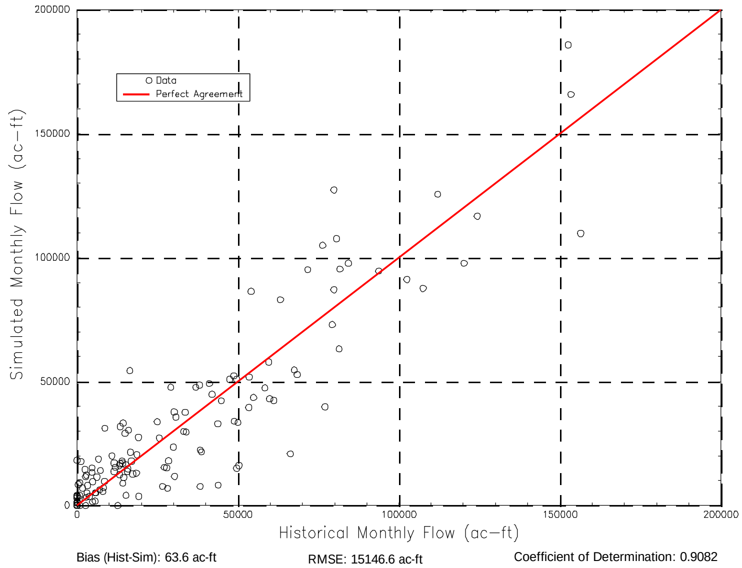

Figure 6.1.7 X-Y Plot of SFWMM Simulated Monthly Everglades Agricultural Area Supplemental Flow and Historical Data (1979-1989)